



Technical Appendix B

Analysis of Data from Home Inspector Survey on Residential Earthquake Retrofit Rates

During six months in 1998, members of the American Society of Home Inspectors (ASHI) helped ABAG by collecting data on all homes they inspect for sale built prior to 1960, as well as on all apartments, regardless of age. The inspectors were asked to fill out a simple one-page form (a copy of which is on the following page).¹ The inspectors filled out a total of 341 usable surveys, which are described on the following pages.

The survey was used in several ways, including:

- ◆ to document skewing of results of the survey of single-family homeowners related to the percentage of homeowners that have retrofitted (see ABAG Analysis of Data from a Survey of Owners of Single-Family Homes – Technical Appendix A);
- ◆ to estimate, in conjunction with that homeowner survey, the percentage of homes that have been adequately retrofitted, as well as those that have had some retrofit work performed on them;
- ◆ to estimate the extent to which homes are being improperly, or inadequately, retrofitted; and
- ◆ to serve as one source of information on retrofitting of multifamily (versus single-family) homes.

Although the survey of single-family homeowners indicated that some retrofit work has occurred on over three-fourths of the older homes in the urban East Bay, this ASHI survey documents skewing and estimates these numbers are high. Still, approximately half of the older homes probably have had some retrofit work, a number much higher than we might have estimated without this information. However, only a third-to-half of these homes with some retrofit work have had reasonably adequate work. Retrofit rates for small multifamily residential buildings in Berkeley approach that of single-family homes, while the retrofit rates in Oakland for multifamily buildings are much lower.

¹ ASHI members did not charge for this service, but requested that ABAG help organize a special training class for their members. The class was held on Saturday, February 20, 1999.

FIGURE B1: ABAG Residential Earthquake Safety Information Form

<p>BACKGROUND INFORMATION</p> <p>City _____</p> <p>Address _____ <i>(round address to nearest 100 – that is, 844 Oak St. would become 800 Oak St.)</i></p> <p>Inspection Date _____</p> <p>Owner Occupied?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know or not available </p>	<p>WOOD-FRAME HOUSING DATA</p> <p>1. Was there a significant addition to this building after its original construction?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes <i>(use this column for the addition)</i> <input type="checkbox"/> No </p> <p style="text-align: right;">↓</p> <p>2. Is there a crawl space?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes, more than 48" <input type="checkbox"/> Yes, less than 48" <input type="checkbox"/> No or inaccessible </p> <p>3. Foundation material</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Brick <input type="checkbox"/> Concrete (poured or block) <input type="checkbox"/> Other </p> <p>4. Are there bolts attaching the frame to the foundation?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes ↓ Are there washers? <input type="checkbox"/> Square <input type="checkbox"/> Round <input type="checkbox"/> None <input type="checkbox"/> No <input type="checkbox"/> Hidden or unknown </p> <p>5. In the crawl space or parking area, is there plywood sheathing to resist lateral movement on the <i>inside</i> face of the cripple wall?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes, some on all walls <input type="checkbox"/> Yes, but only on 1 or 2 walls <input type="checkbox"/> No <input type="checkbox"/> No cripple wall or inaccessible </p> <p>6. Was the building retrofitted with a steel frame around the parking/garage door opening?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes <input type="checkbox"/> No </p> <p>7. Did you observe damage or deterioration that is likely to affect the performance of this building in an earthquake?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes <input type="checkbox"/> No </p> <p>8. Was there a referral to a licensed professional due to structural or foundation concerns?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes <input type="checkbox"/> No </p>
<p>GENERAL QUESTIONS</p> <p>1. Number of above-grade stories _____ <i>(fill in number, including above-grade parking)</i> <i>(split-level = 1½)</i></p> <p>2. Number of housing units _____</p> <p>3. Approximate square footage _____</p> <p>4. Ground floor use <i>(check all that apply)</i></p> <p style="padding-left: 20px;"> <input type="checkbox"/> Residential <input type="checkbox"/> Commercial <input type="checkbox"/> Parking </p> <p>5. Decade of original construction _____ <i>(that is, 1950s, etc.)</i></p> <p>6. Has the water heater been braced to resist lateral movement?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes ↓ Number of straps _____ <input type="checkbox"/> No </p> <p>7. Have the chimneys been braced?</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Yes, all <input type="checkbox"/> Yes, some of them <input type="checkbox"/> Not braced <input type="checkbox"/> No chimney </p> <p>8. Above-grade construction is primarily –</p> <p style="padding-left: 20px;"> <input type="checkbox"/> Wood frame <i>(continue with next column)</i> <input type="checkbox"/> Other frame or wall type <i>(concrete, steel, masonry) (STOP HERE)</i> </p>	
<p>COMMENTS:</p> 	

Survey Data

As shown in the following table, participation was excellent among inspection companies in the urban East Bay, particularly for Alameda, Oakland and Berkeley. However, few surveys were completed for homes in the remaining communities which were targeted for the homeowner survey. As of January 21, 1999, 341 surveys had been entered into a database for analysis. Of the 341 surveys,

- ◆ 138 surveys had been returned for Oakland,
- ◆ 78 surveys had been returned for Berkeley,
- ◆ 41 surveys had been returned for Alameda,
- ◆ 16 surveys had been returned for San Leandro,
- ◆ 15 surveys had been returned for all other cities that had received ABAG's homeowner survey, with no more than 10 surveys from any single city, and
- ◆ 53 surveys had been returned for all other cities that had *not* received ABAG's homeowner survey.

TABLE B1: Data Obtained by ASHI Inspectors by Jurisdiction

Jurisdictions Included in Homeowner Survey			Jurisdictions Not Included in Homeowner Survey		
<i>Jurisdiction</i>	<i>#of Responses</i>	<i>% of Total</i>	<i>Jurisdiction</i>	<i>#of Responses</i>	<i>% of Total</i>
Oakland	138	40.5%	El Cerrito	16	4.7%
Berkeley	78	22.9%	Albany	9	2.6%
Alameda	41	12.0%	Piedmont	9	2.6%
San Leandro	16	4.7%	Kensington	5	1.5%
Richmond	7	2.1%	Castro Valley	3	0.9%
Concord	4	1.2%	Moraga	2	0.6%
San Francisco	3	0.9%	San Pablo	2	0.6%
San Jose	1	0.3%	Fairfax	1	0.3%
<i>Total in Survey Cities</i>	<i>288</i>	<i>84.5%</i>	Hayward	1	0.3%
			Lafayette	1	0.3%
			Los Altos	1	0.3%
			Pleasant Hill	1	0.3%
			San Anselmo	1	0.3%
			(Blank)	1	0.3%
			<i>Total in Non-Survey Cities</i>	<i>53</i>	<i>15.5%</i>

Responses to Individual Questions

Table B2 on the following three pages summarizes the results for individual questions.

TABLE B2: Responses to ASHI Survey Questions

[Note: Values in “total” column include cities other than the four listed;
percentages may not add to 100% due to rounding errors.]

Owner occupied?									
Response	Oakland		Berkeley		Alameda		San Leandro		Total
Yes	83	61.0%	48	62.3%	24	60.0%	9	56.3%	203 60.2%
No	52	38.2%	28	36.4%	16	40.0%	5	31.3%	130 38.6%
Don't know	1	0.7%	1	1.3%	0	0.0%	2	12.5%	4 1.2%
<i>Total</i>	136		77		40		16		337
1. Number of above-grade stories									
Response	Oakland		Berkeley		Alameda		San Leandro		Total
1(includes 1.5)	56	38.9%	36	42.4%	21	42.0%	14	58.3%	168 49.4%
2 (includes 2.5)	63	43.8%	33	38.8%	22	44.0%	2	8.3%	133 39.1%
3+	25	17.4%	16	18.8%	7	14.0%	8	33.3%	39 11.5%
<i>Total</i>	144		85		50		24		340
2. Number of housing units									
Response	Oakland		Berkeley		Alameda		San Leandro		Total
1	118	85.5%	58	75.3%	36	87.8%	13	81.3%	287 84.4%
2-3	12	8.7%	14	18.2%	5	12.2%	1	6.3%	35 10.3%
4+	8	5.8%	5	6.5%	0	0.0%	2	12.5%	18 5.3%
<i>Total</i>	138		77		41		16		340
3. Approximate square footage									
Response	Oakland		Berkeley		Alameda		San Leandro		Total
<1000	5	3.7%	6	7.8%	1	2.4%	0	0.0%	287 76.9%
1000-1999	78	57.4%	42	54.5%	28	68.3%	13	81.3%	35 9.4%
2000-2999	36	26.5%	18	23.4%	11	26.8%	1	6.3%	18 4.8%
3000+	17	12.5%	11	14.3%	1	2.4%	2	12.5%	33 8.8%
<i>Total</i>	136		77		41		16		373
4. Ground floor use (check all that apply)									
Response	Oakland		Berkeley		Alameda		San Leandro		Total
Residential	123	89.1%	66	85.7%	41	100.0%	15	93.8%	308 90.6%
Commercial	1	0.7%	2	2.6%	0	0.0%	0	0.0%	3 0.9%
Parking	47	34.1%	15	19.5%	17	41.5%	2	12.5%	113 33.2%
<i>Total buildings</i>	138		77		41		16		340
NOTE: Some buildings had more than one ground floor use.									
5. Decade of original construction									
Response	Oakland		Berkeley		Alameda		San Leandro		Total
<1920	21	15.2%	20	25.6%	10	24.4%	0	0.0%	54 15.8%
1920-1939	50	36.2%	38	48.7%	13	31.7%	5	31.3%	122 35.8%
1940-1960	40	29.0%	18	23.1%	6	14.6%	10	62.5%	107 31.4%
1960+	27	19.6%	2	2.6%	12	29.3%	1	6.3%	58 17.0%
<i>Total</i>	138	1	78	1	41	1	16	1	341

TABLE B2: Responses to ASHI Survey Questions (continued)

6. Has the water heater been braced to resist lateral movement?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes	85	62.5%	46	59.7%	25	61.0%	7	46.7%	209	62.0%
No	51	37.5%	31	40.3%	16	39.0%	8	53.3%	128	38.0%
<i>Total</i>	136		77		41		15		337	
If yes, # of straps										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
1	21	26.9%	16	40.0%	13	54.2%	4	80.0%	72	37.9%
2+	57	73.1%	24	60.0%	11	45.8%	1	20.0%	118	62.1%
<i>Total</i>	78		40		24		5		190	
7. Have all the chimneys been braced?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes, all	13	9.6%	7	9.6%	2	4.9%	0	0.0%	31	9.3%
Yes, some of them	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	0.3%
Not braced	94	69.6%	53	72.6%	32	78.0%	12	75.0%	238	71.7%
No chimney	28	20.7%	13	17.8%	6	14.6%	4	25.0%	62	18.7%
<i>Total</i>	135		73		41		16		332	
8. Above-grade construction is primarily--										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Wood frame	138	97.9%	76	100.0%	40	100.0%	16	100.0%	334	98.8%
Other frame or wall type	3	2.1%	0	0.0%	0	0.0%	0	0.0%	4	1.2%
<i>Total</i>	141		76		40		16		338	

Wood-Frame Housing Data

1. Was there a significant addition to this building after its original construction?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes	47	34.6%	27	34.6%	20	50.0%	6	37.5%	126	37.4%
No	89	65.4%	51	65.4%	20	50.0%	10	62.5%	211	62.6%
<i>Total</i>	136		78		40		16		337	
2. Is there a crawl space?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes, more than 48"	45	33.3%	20	25.6%	6	20.0%	0	0.0%	87	26.0%
Yes, less than 48"	75	55.6%	53	67.9%	21	70.0%	14	87.5%	202	60.3%
No or inaccessible	15	11.1%	5	6.4%	3	10.0%	2	12.5%	46	13.7%
<i>Total</i>	135		78		30		16		335	
3. Foundation material										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Brick	4	2.9%	5	6.5%	5	12.5%	0	0.0%	14	4.2%
Concrete (poured or block)	132	97.1%	72	93.5%	35	87.5%	16	100.0%	321	95.8%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
<i>Total</i>	136		77		40		16		335	

TABLE B2: Responses to ASHI Survey Questions (continued)

4. Are there bolts attaching the frame to the foundation?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes	95	70.4%	55	73.3%	21	53.8%	11	73.3%	237	71.8%
No	33	24.4%	15	20.0%	12	30.8%	2	13.3%	68	20.6%
Hidden or unknown	7	5.2%	5	6.7%	6	15.4%	2	13.3%	25	7.6%
Total	135		75		39		15		330	
If yes, are there washers?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Square	1	1.3%	1	2.1%	0	0.0%	0	0.0%	3	1.5%
Round	69	87.3%	47	97.9%	17	94.4%	9	90.0%	189	91.7%
None	9	11.4%	0	0.0%	1	5.6%	1	10.0%	14	6.8%
Total	79		48		18		10		206	
5. In the crawl space or parking area, is there plywood sheathing to resist lateral movement on the inside face of the cripple wall?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes, some on all walls	28	20.7%	28	37.3%	5	12.5%	0	0.0%	74	22.3%
Yes, but only on 1 or 2 walls	11	8.1%	12	16.0%	0	0.0%	1	6.3%	28	8.4%
No	83	61.5%	30	40.0%	19	47.5%	10	62.5%	172	51.8%
No cripple wall or inaccessible	13	9.6%	5	6.7%	16	40.0%	5	31.3%	58	17.5%
Total	135		75		40		16		332	
6. Was the building retrofitted with a steel frame around the parking/garage door opening?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes	2	1.7%	2	3.2%	0	0.0%	0	0.0%	4	1.4%
No	117	98.3%	61	96.8%	32	100.0%	13	100.0%	281	98.6%
Total	119		63		32		13		285	
7. Did you observe damage or deterioration that is likely to affect the performance of this building in an earthquake?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes	35	25.7%	21	27.6%	10	24.4%	4	25.0%	81	24.1%
No	101	74.3%	55	72.4%	31	75.6%	12	75.0%	255	75.9%
Total	136		76		41		16		336	
8. Was there a referral to a licensed professional due to structural or foundation concerns?										
Response	Oakland		Berkeley		Alameda		San Leandro		Total	
Yes	48	35.6%	28	37.3%	10	25.0%	6	37.5%	103	31.0%
No	87	64.4%	47	62.7%	30	75.0%	10	62.5%	229	69.0%
Total	135		75		40		16		332	

Data on Retrofit Rates for Single-Family Homes

When looking at the retrofit rates for single-family homes built prior to 1960 with the presence or absence of visible retrofit work, the number of usable surveys drops from 341 to 208. The two jurisdictions with large enough samples to be used for even somewhat *statistically significant* analyses are Oakland and Berkeley. However, we have also tabulated data for Alameda and San Leandro to see if *basic trends* continue to hold.

As with the homeowner survey, we defined a home as having had some retrofit work if the home was built prior to 1950 and had bolts, or was built prior to 1960 and had plywood on cripple walls. As can be seen from Table B3.1, below, there is a significant difference between the percentage of homes identified as having some retrofit work in the ASHI survey versus the ABAG homeowner survey. One explanation for part of the difference is if one assumes that people who had included seismic strengthening as part of an addition told us that they had retrofitted, even if they had not upgraded the original portion of their home, as shown in the middle column of Table B3.1, below. We are inclined to assume this to be the case. If one narrows the definition of retrofit to include only homes with plywood in the crawlspace, the retrofit rate drops further, as shown in Table B3.2, below. The percentages from the ASHI survey are consistently lower than in the homeowner survey.

**TABLE B3: A Comparison of Rates of Retrofit Work (Partial or Adequate)
in Selected Urban East Bay Cities**

Table B3.1: Some Retrofit Work

City	ASHI Inspection Survey Partial Retrofit Rate (not incl. Additions)	ASHI Inspection Survey Partial Retrofit Rate (incl. additions)	ABAG Homeowner Survey Partial Retrofit Rate
Berkeley	79 % (42 / 53)	83 % (44 / 53)	82.8% (149 / 180)
Oakland	44 % (36 / 81)	48 % (39 / 81)	75.0% (108 / 144)
Alameda	52 % (11 / 21)	67 % (14 / 21)	78.8% (93 / 118)
San Leandro	46 % (6 / 13)	46 % (6 / 13)	52.8% (57 / 108)

Table B3.2: Reasonably Adequate Retrofit Work

City	ASHI Inspection Survey Retrofit Rate (not incl. additions; must include bolts and, if crawlspace, plywood on ALL walls)	ASHI Inspection Survey Retrofit Rate (not incl. additions; may include plywood on only one wall if crawlspace)	ABAG Homeowner Survey Reasonably Adequate Retrofit Rate (must include bolts, and, if crawlspace, plywood)
Berkeley	38 % (20 / 53)	55 % (29 / 53)	62.8% (113 / 180)
Oakland	17 % (14 / 81)	25 % (20 / 81)	51.4% (74 / 144)
Alameda	19 % (4 / 21)	19 % (4 / 21)	45.8% (54 / 118)
San Leandro	31 % (4 / 13)	31 % (4 / 13)	20.4% (22 / 108)

There is the possibility of distorted responses, or *skewing*, in both surveys. The ABAG survey has the potential of distortion due to a tendency of those who have not retrofitted to not reply to

the survey. (The response rate for Berkeley was 41% and for Oakland was 27%.) Distortion is also possible in the ASHI survey if homes currently for sale tend to have been sold more recently than homes in general. Thus, to the extent that Berkeley's program targets retrofitting homes during the sale process, the retrofit rate in Berkeley may be slightly exaggerated. However, skewing of the ASHI survey data should be significantly lower than for the homeowner survey.

However, in spite of all of these sources of error, it is reasonable to assume that half of the homes in the urban east Bay have had some retrofit work! This number is far higher than anticipated prior to the start of this work.

Finally, one can calculate a "follow-through" rate, the ratio of homes with reasonably adequate work (first column of Table B3.2) to those that had some retrofit work done (middle column of Table B3.1). ***Homes in the cities of Berkeley and San Leandro had higher percentages of "follow through"*** (45% and 67%) than in Oakland (36%) or Alameda (29%). We calculated this follow-through rate using data from the homeowner survey as a comparison to see if the trend can be seen in that larger database. In this case, the percentages for Berkeley (76%), Oakland (69%), Alameda (58%) are far higher than in the ASHI database. They reflect the skewing of the data toward people who had done work, and the general trend of overstating the amount of work that had occurred. San Leandro's (39%) is lower than in the ASHI survey, but the ASHI survey data is based on so few surveys that it is not particularly significant.

Estimation of "Actual" Retrofit Rates for Single-Family Homes

Assuming that the ASHI survey data are reasonably accurate for the cities of Berkeley and Oakland, it is possible to develop a formula to correct the skewing of the homeowner survey data. That formula can then be used to estimate the "actual" (or un-skewed) retrofit rate for the other communities whose homeowners were surveyed. This formula uses data on retrofit rates from both surveys for the these two cities, as well as the response rate for the homeowner survey.

TABLE B4: Key Single-Family Survey Data for Oakland and Berkeley

Table B4.1: Some Retrofit Work

City	ASHI Inspection Survey Partial Retrofit Rate (including additions)	ABAG Homeowner Survey Partial Retrofit Rate	ABAG Homeowner Survey Response Rate
Berkeley	83 %	82.8 %	41%
Oakland	48 %	75.0 %	27%

Table B4.2: Reasonably Adequate Retrofit Work

City	ASHI Inspection Survey Retrofit Rate (not including additions; plywood on all walls if crawlspace)	ABAG Homeowner Survey Reasonably Adequate Retrofit Rate (must include bolts, and, if crawlspace, plywood)	ABAG Homeowner Survey Response Rate
Berkeley	38 %	62.8%	41%
Oakland	17 %	51.4 %	27%

TABLE B5: Predicted “Actual” Retrofit Rate for Targeted Cities**Table B5.1: Some Retrofit Work**

City	ASHI Inspection Survey Retrofit Rate (in %)	ABAG Homeowner Survey Retrofit Rate (in %)	ABAG Homeowner Survey Response Rate (in %)	ABAG Predicted “Actual” Retrofit Rate (in %)
Oakland	48	75.0	27.0	48
Berkeley	83	82.8	40.8	83
Alameda	67	78.8	28.4	53
San Leandro	46	52.8	23.6	31
San Francisco	Not available	73.6	23.1	42
Daly City	Not available	42.1	28.7	28
Palo Alto	Not available	62.3	35.6	52
Los Gatos	Not available	82.2	32.4	62
Santa Clara	Not available	29.2	21.0	16
San Jose	Not available	57.2	27.4	37
Richmond	Not available	58.4	24.7	35
Concord	Not available	28.7	25.2	17
Napa	Not available	39.7	22.0	22
Santa Rosa	Not available	56.4	29.6	39
Lexington Hills	Not available	56.7	27.0	36
San Lorenzo	Not available	38.1	23.6	22
Crockett	Not available	53.1	32.7	40

Table B5.2: Reasonably Adequate Retrofit Work

City	ASHI Inspection Survey Retrofit Rate	ABAG Homeowner Survey Retrofit Rate	ABAG Homeowner Survey Response Rate	ABAG Predicted “Actual” Retrofit Rate
Oakland	17	51.4	27.0	17
Berkeley	38	62.8	40.8	37
Alameda	19	45.8	28.4	16
San Leandro	31	20.4	23.6	6
San Francisco	Not available	50.3	23.1	14
Daly City	Not available	23.4	28.7	8
Palo Alto	Not available	36.4	35.6	17
Los Gatos	Not available	48.9	32.4	20
Santa Clara	Not available	12.3	21.0	3
San Jose	Not available	18.4	27.4	6
Richmond	Not available	17.8	24.7	5
Concord	Not available	24.1	25.2	7
Napa	Not available	12.8	22.0	3
Santa Rosa	Not available	15.5	29.6	6
Lexington Hills	Not available	23.3	27.0	8
San Lorenzo	Not available	16.7	23.6	5
Crockett	Not available	37.5	32.7	15

Notes on Development of Formula to Estimate “Actual” Retrofit Rates for Single-Family Homes –

Initially, we calculated the simple ratios between the homeowner survey retrofit rates and the ASHI survey retrofit rates. These ratios (1.0 for Berkeley and 1.6 for Oakland for partial retrofits, for example) are quite different.

Our second attempt was slightly more complex. We used the ASHI data to calculate the retrofit rate for those homeowners who had not completed the survey. This nonrespondent retrofit rate (HSNRR) can be calculated as:

$$(RR \times HSRR) + (1 - RR) \times (HSNRR) = ARR$$

where:

RR = Homeowner Survey Response Rate

HSRR = Homeowner Survey Retrofit Rate

HSNRR = Homeowner Survey Nonrespondent Retrofit Rate

ARR = ASHI Retrofit Rate

The nonrespondent retrofit rate for partial retrofits for Berkeley is 78.6%, and for Oakland is 36.6%. Again, these numbers are quite different.

We then calculated the ratio between the nonrespondent and respondent retrofit rates as 1.09 for Berkeley and 2.05 for Oakland. Again, these ratios were quite different and pointed to a more complex relationship.

Next, we assumed that we could define a base retrofit rate which could be added to the nonrespondent value to create a workable formula. Again, these efforts failed.

These calculations were followed by a series of calculations trying to use the differences between the respondents' answers to questions about income and education with census data and data from the homeowner survey about the influence of income and education on retrofit to create a much more complex formula. None of these calculations proved simple or informative.

Our best effort at developing a formula assumes that the homeowner survey response rate can be used to create a formula, $R + K \times (RR)$, where:

R = Base retrofit ratio

K = Importance factor for the response rate

RR = Response rate

This ratio can be used to calculate the retrofit rate for unanswered surveys. That nonrespondent retrofit rate can then be used to calculate the estimated “actual” retrofit rate. The estimated “actual” retrofit rates for the surveyed communities are contained in Table B5, based on:

for some retrofit work – R=3.86 and K=7.0

for reasonably adequate work – R=29.4 and K=64.3

Comparison of Retrofit Rates of Single-Family Homes Versus Multifamily Homes and Mobile Homes

Very little actual information exists on retrofit rates of mobile homes and multifamily apartments or condominiums. The following three sources summarize the existing information.

ASHI Inspection Survey Data

The ASHI survey collected some data on 53 small multifamily buildings containing 745 units, including 19 buildings with 63 units in Berkeley and 20 buildings with 176 units in Oakland. However, the survey data on 3 buildings containing 8 units in Berkeley and 4 buildings containing 126 units in Oakland was incomplete. Data on the remaining buildings was used to estimate the partial and “adequate” retrofit rates for these buildings and units and to compare it with the retrofit rate for single-family homes, as shown in Tables B6 and B7. The survey data can be analyzed for all multifamily buildings in these two cities, or limited to those buildings constructed prior to 1960. (Limiting the analysis to buildings constructed prior to 1960 further limits the data to 17 buildings with 47 units in Berkeley, and 13 buildings with 44 units in Oakland.) The definition of partial retrofit was the same as for single-family homes, but the definition of adequate retrofit was modified. Multifamily buildings with ground-floor parking

and with living units above that parking had to have some strengthening of the garage opening to be considered adequately retrofitted.

TABLE B6: Key Multifamily ASHI Inspection Survey Data for Oakland and Berkeley

TABLE B6.1 Data for ALL Multifamily Buildings

City	Fraction at Least Partially Retrofitted		Partial Retrofit Rate for Multifamily Housing		Fraction Adequately Retrofitted		Adequate Retrofit Rate for Multifamily Housing	
	Buildings	Units	Buildings	Units	Buildings	Units	Buildings	Units
Berkeley	11/16	43/55	69%	78%	6/16	18/55	38%	33%
Oakland	2/16	16/50	12%	32%	0/16	0/50	0 %	0 %

TABLE B6.2 Data for Multifamily Buildings Built Prior to 1960

City	Fraction at Least Partially Retrofitted Built Pre-1960		Partial Retrofit Rate for Pre-1960 Multi-family Housing		Fraction “Adequately” Retrofitted Built Pre-1960		“Adequate” Retrofit Rate for Pre-1960 Multi-family Housing	
	Buildings	Units	Buildings	Units	Buildings	Units	Buildings	Units
Berkeley	10/14	29/39	71%	74%	6/14	18/39	43%	46%
Oakland	2/12	16/40	17%	40%	0/12	0/40	0 %	0 %

It is interesting that the ratio of retrofit rates for multifamily versus single-family construction is very different for these two cities, as shown in Table B7, below. Unfortunately, these data are for so few buildings and units that they are not statistically valid in documenting a high retrofit rate for small multifamily residential buildings in Berkeley. However, the general conclusion that retrofit rates for multifamily housing is less than for single-family homes is valid.

TABLE B7: Single-Family Vs. Multifamily ASHI Survey Data for Oakland and Berkeley

Table B7.1: Some Retrofit Work

City	Single-Family Retrofit Rates (Some Retrofit Work)	Multifamily Building Retrofit Rates (Some Retrofit Work)	Ratio of Retrofit Rates (Multifamily / Single)
Berkeley	83 %	69 %	0.8
Oakland	48 %	12 %	0.3

Table B7.1: Reasonably Adequate Retrofit Work

City	Single-Family Retrofit Rates (Reasonably Adequate Work)	Multifamily Building Retrofit Rates (Reasonably Adequate Work)	Ratio of Retrofit Rates (Multifamily / Single)
Berkeley	38 %	33 %	0.9
Oakland	17 %	0 %	0

ABAG Homeowner Survey Data

As discussed earlier, ABAG surveyed single-family homeowners in 17 communities. One question on that survey is particularly relevant to this discussion - whether or not the owner currently lived in or rented out the home. Interestingly, the rate of performing some retrofit among owner-occupants responding to the survey was 63.0% versus 41.0% for those renting out the home; the rate of reasonably adequate retrofit was 35.7% versus 21.4% for those renting out the home. The issue of ownership may therefore be partially responsible for a discrepancy between single-family and multifamily retrofit rates apparent from the ASHI data.

Given the relative lack of data from other sources, we decided to conduct a survey of multifamily residential buildings in Berkeley and Oakland during the summer of 1999. (See Technical Appendix D for further information on this survey.) As with the single-family homeowners survey, the retrofit information is highly skewed. (In spite of the small amount of data obtained from the ASHI survey, it is potentially more accurate.) However, two relationships from that survey are highly relevant to this discussion. First, the retrofit rate for 2-4 unit buildings is far higher than for 5 or more unit buildings in Berkeley, pointing to a potentially large impact of Berkeley's property transfer tax rebate program (described briefly below). Second, the retrofit rate for 2-4 unit buildings may be higher than for single-family homes in Berkeley, pointing to a greater impact of that program on investment properties than on homes with owner-occupants.

Data from the City of Berkeley Financial Incentive Program

A 1992 City of Berkeley ordinance waives permit fees paid to the city for seismic retrofits on non-strengthened single-family residences, multifamily residential buildings of up to four dwelling units, and unreinforced masonry structures. ***Since 1996, when detailed data have been collected for these projects, 1,239 were for single-family homes, but 324 were for multifamily projects.*** Given that there are approximately the same number of single-family units and multifamily units (not buildings) in the City, these data would seem to confirm that the high retrofit rate for multifamily buildings in Berkeley is "real." The financial incentive program may be responsible for triggering these retrofits. (See Technical Appendix C for further information on this program.)

Santa Cruz County Brace for the Quake Program Data

The final source of retrofit information is data collected by FEMA in monitoring Santa Cruz County's ***Brace for the Quake*** program.

The retrofit program provided grants to 412 single-family homes. Although any home built prior to 1980 might be considered a candidate for the program, it was targeted to pre-World War II units. The data suggest that several 1950s vintage homes were among the homes retrofitted. Thus, it seems reasonable to assume that the "universe" of homeowners which might apply for funding was the number of single-family homes built prior to 1960. However, the universe of multifamily units and mobile homes did not have a specific age-related cutoff. 1990 Census data can therefore be used to estimate the number of units available for retrofit, and the increase in retrofitting that can be attributed to this program.

TABLE B8: Santa Cruz County *Brace for the Quake* Program Data

City	Number of Units in County	Number of Units Retrofitted	Retrofit Rates
Single-Family	20,578	412	2.0%
Multifamily	17,554	331	1.9%
Mobile Homes	7,157	451	6.3%

Again, this information seems to suggest that the retrofit rates for single-family versus multifamily units can be similar given financial incentives. Another possible explanation for this similarity is that these numbers represent increases in retrofitting from 1992 until 1996. To the extent that many single-family homes might have been retrofitted prior to 1992, the actually number of unretrofitted single-family homes needing retrofit may have been smaller.

The retrofit rate for mobile homes is the highest for the three types of buildings. According to FEMA, there was almost no outreach on the program by the County, except for facilitating a few newspaper stories. The mobile home success rate was almost entirely due to outreach by the contractors. One contractor, in particular, did most of the mobile homes. Fortunately, both the County and FEMA were pleased with this contractor, for they did high quality work. They also had good marketing and convinced people to sign up. All installations were independently inspected – which, for the mobile homes, was usually a State inspector. As with the multifamily retrofit rates, it is likely that one of the reasons for the high incremental increase in retrofitting of mobile homes may have been the relatively low retrofit rate prior to the onset of the program. (See Technical Appendix C for further information on this program.)